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SOME STRIKING ILLUSIONS OF MOVEMENT OF A SINGLE LIGHT ON MOUNTAINS

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It is now well known that our visual perception of any object in nature is determined not only by the rays of light from the objects that impinge upon the retina, but also by numerous other factors. Seeing is not a process of some "mind" looking out through the eyes upon the objects. The objects perceived are not so simply given in the objective world. Perception is quite a different process from such a passive procedure. This fact is more easily recognized in auditory than in visual perception. It is obvious that when we hear the robin outside in the spring we must be associating, though not consciously, visual factors with the sound, or how could we know that the sound is that of a bird of a certain color, size, and in a certain location? One also easily understands that such matters as the position of the head and the relative strength of the stimuli coming to the two ears are important in our determination of the direction of the source of the sound.

A large variety of factors has been shown to be of importance in visual perception. The story of the scientific advance in this field makes a chapter of real gain in the history of psychology. The location in the visual field of a dot on the wall, for instance, is determined in part by the position on the retina which it stimulates, or on which its image falls. If the dot is near the ceiling in front of one it stimulates the lower part of the retina; if it is at the right its image falls on the left portion of the retina; and so on. In consequence of this simple result of having a lens, the image on the retina of any perceived object, as is well known, is inverted. The old question of how the image becomes "turned right side up again" in getting to the cerebral cortex, or the "center of vision," is nonsense, and reveals a total misapprehension of the matter. No image is thus transmitted at all, but rather every part of the area of the retina stimulated is to be thought of as a particular case of the general law of the location of visual objects to which reference is made in

the early part of this paragraph. The tendency is to locate any object stimulating the retina, along the line determined by the point stimulated and the nodal point on the lens through which the ray passes. Since any point on an object stimulates a particular point on the retina, the various tendencies are co-ordinated in a way to give a total percept of the object—a certain shape, outline, volume, direction and distance consciousness.

The eye tends reflexly to turn so that the image of any stimulating dot falls on the fovea. Whether this tendency is wholly innate or is partly acquired, is not fully known. Or, better, how far the innate tendency is modified by experience in various animals and in man is a matter that is not settled. Certain innate reflex tendencies to eye movements of this kind are not to be doubted in some species of animals.

This suggests, too, that the eyes are not stationary with reference to any given position of the head, and the head is not determined by any given fixed position of the body. The direction of the visual object is therefore determined not only by the place of stimulation on the retina—for an object may be seen to move even though the eyes are fixed on it and are moving with it, in which case the image does not move across the retina—but also by numerous kinesthetic sensations. Normally various other factors are also important in the location of a moving object, such, for instance, as the images of other things over which the object is passing.

It is obvious, moreover, that all the diverging rays from any dot in the visual field must be brought to a focus on the retina, otherwise the effect would be that of a faint stimulation of the entire retina and the stimulations of several objects would all be superimposed and in no case distinguishable. This is the same thing as saying that the objects would appear blurred, or completely fused together. This focusing of all the diverging rays from any particular point in the visual field is effected by the refraction of the light rays as they pass through the lens. This requires careful adjustment of the lens for different distances, an adjustment that is brought about involuntarily by contractions or relaxations of the ciliary muscles. It must also be remembered that the perception is binocular. Therefore movements of co-ordination of the two eyes must play an important part. Any irregularities in any one of all these processes, due to fatigue, to unusual strain, or to pathological conditions must, of course, interfere with vision. Of such interferences resulting in illusions of different kinds and degrees Dr. H. A. Carr

has given and discussed a number of illustrations.¹ Illusions of depth have been known in some cases to be under voluntary control, as are also occasionally the clicks produced in the ears when swallowing, by the contractions of the tensor tympani muscles.

The perception of distance, or of depth, is dependent upon a large number of associated factors, such as color (since colors change with distance), clearness of outline, brightnesses and shadows, superposition of near objects on farther ones. Then, too, some more definitely kinesthetic factors, or impulses from muscular activity, play an important rôle: the apparent size of objects whose size is known, the relative size of various objects at different distances, and the apparent rate of movement of objects whose rate is fairly well known. A description of the rôle in perception of each of these factors would lead us too far from our special purpose. They are merely mentioned here to suggest the extreme complexity of visual perception.

Yet it must be emphatically stated here that perception is not a logical process, or even a matter of judgment, at all. We do not take note explicitly of all, and usually not of any, of these factors and then *conclude* that the object is located in such and such a direction at a distance of about thirty feet! This happens only when perception somehow misleads us. The whole process of perception is immediate. Instead of seeing in the distance a person known to be six feet high, noting that he appears very small, that some nearer objects conceal part of him as their outlines overlap his, that though walking he seems to move very slowly, that the outline of his figure is vague, that the strains of our ciliary and inner recti muscles are very slight, and so on, and then judging that he is so many blocks away, slightly to our right,—instead of such a deliberate process we immediately see him in a certain direction and at a recognized distance. The whole situation flashes into consciousness instantaneously, and does not come by any sort of inferential process whatever. This is what makes illusion not only so easy but so absolutely deceptive and stunning. We, of course, experience numerous minor and partial illusions which never are recognized as such. This is no doubt true with respect to any of the senses. It is really only when confusions and inconsistencies arise in our experiences that our attention is drawn to certain imperfections in perception. Even in such cases analytic studies

¹ *Psychol. Rev. Mon.*, Vol. VII, No. 3; *Psychol. Rev.*, XIII., 258; *ibid.*, XV., 139; *ibid.*, XVI., 219. References to other writers are given.

in the psychological laboratories are necessary as a rule for a full understanding of the illusion.

The illusions now to be described are so interesting in themselves and cast so much light on certain larger problems of our orientation that it is thought worth while to report them, even though they were experienced so long ago that on many details where record is incomplete a high degree of accuracy in description is not possible. One of the illusions occurred in the writer's childhood and is purely a matter of memory. Only matters about which there is a high degree of certainty are given, however. The other illusion is a matter of record, but many of the details as to rate and direction of movement, the time for the illusion to develop, and so on, are lacking, some of the problems relating to which having been developed more recently in researches. It is hoped that the report, with such imperfections as it may have, may lead to the obtaining of more careful descriptions of similar illusions by those who chance to observe them.

On a dark rainy evening in December, 1909, from about 8 to 10 o'clock, a visual illusion of motion of striking proportions was witnessed by two high school students and four adults, two men of the latter being college students and the others being the writer and his wife. The illusion consisted in seeing movements of a stationary light on a mountain east of Provo, Utah. It first came to the attention of the writer and he called the other persons to witness the phenomenon. The part of the Wasatch Range on which the light was located is nearly directly east of the north side of the city. The observers were viewing the light from a position in the northeast part of the city, the house being located on a corner of Fourth East and Seventh North streets. The visible portion of the mountain on which the light was located has a height of about 1,000 meters (3,280.8 ft.) above the point from which the observation was made, and from this point an air line to the light, which was approximately half way up the mountain side, is about 2,000 meters, or something over a mile. The intense darkness of the night made only the outline of the mountain visible, the whole side from base to top being a perfectly dark field. This condition is well known to be most favorable for the illusion.

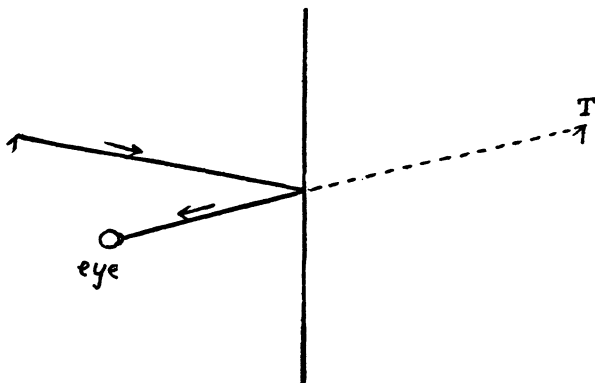
The writer watched the light some time himself before calling out the other observers. The phenomenon was really wonderful. One acquainted with mountain climbing knows that it is a slow, tedious process; yet here was a small, brilliant light, presenting much the appearance of a distant lan-

tern, moving about on the mountain side with an amazing speed. The light was, of course, larger than an ordinary lantern so far away would appear. The movements were very irregular, now and then presenting the appearance of one hesitating to think which direction to follow, *i. e.*, the movements were very much like the voluntary behavior of an individual rather than like some mechanical process. Frequently the light would, after such apparent deliberation, suddenly shoot out in a certain direction at a great speed. These extensive movements were always more or less up or down, frequently going obliquely to the sides in a direction making an angle not to exceed 30 or 40 degrees with a vertical line. Often it would seem to approach the upper edge of the mountain's outline, or, if going in the other direction, its base; but it, of course, regularly stopped and moved back. The backward movements were seldom, if ever, a direct retracing of the other path; *i. e.*, if we call the movements away from the true position of the light the out-movements and those bringing it back the in-movements, it could be said that seldom would the in-movements retrace even a part of the out-movements. The larger shooting movements were, moreover, not usually uniform in direction, but they were frequently subject to smaller irregularities. For instance, the light might shoot rapidly up slightly to the right and then turn somewhat at a particular place to this side or that; it might then pass downward in a more nearly perpendicular direction, and then up toward the original position. It should also be noted that occasionally movements up or down might go on for a short time without seeming to bring the light nearer the edge of the mountain; this, it seems to me, was particularly true when the attention was directed to the edge with a question as to how soon it would be reached. The light always stopped or changed direction before reaching the edge. Just how close it seemed to go I cannot say, because of the contradictory experience just noted.

When the other observers were called all agreed for a short time in their general descriptions of the movement. All seemed to get the illusion very readily, though possibly not immediately. We tried to sight by the edges of trees a few feet away, but in this we had no success. As the edges could not be clearly seen against the dark background afforded by the mountain, the sighting had no tendency whatever to annul the movements of the light. It is, however, possible that the projection of the trees above the image of the mountain, where they could be clearly seen, had the effect

of preventing extensive side movements of the light. Some of the observers were speculating as to whether some one might not be moving the light from a point not far away by means of strings. The high school girl, whose roommate was away, was frightened, regarding the phenomenon as supernatural! Those of us who suspected that the movements were illusory soon got confirmation of their view. Contradictions soon began to arise as descriptions passed beyond mere exclamation to greater accuracy. "There it goes, shooting upward to the right," *A* would say, only to be contradicted by *B*, who would declare that it was at the time actually moving slowly, or, perhaps, that it was going downward. It became evident that no two were having the same illusions.

It was then decided by the writer to arrange apparatus for accurate sighting, so that we could see what effect this would have on the illusion both during the time of sighting and



afterwards,—after the *fact* of the illusion had been clearly established wholly within the experience of each observer. Accordingly a dark east room in the house was chosen for an observation point. The light, it will be recalled, was to our east. In this room a head-rest was constructed a little over a meter from the window. From behind the observer's position, through a small space over and by the side of the door to an illuminated room a triangular ray of light was admitted. This ray was reflected from the window into the observer's eye, as shown in the accompanying figure, so that it would be seen outside of the window (at *T*) in the form of a triangle about four meters from the observer. The head-

rest was so adjusted that the light on the mountain was seen just above the point of the triangle. To any one of us as observer under these conditions the light on the mountain was seen to be absolutely stationary. Immediately, however, on removing his head from the head-rest and getting away from the controlled conditions of observation, the observer would again see the illusion as before. That is, the check of the experimental conditions had only a momentary effect on any observer: *the illusion persisted under normal conditions of observation even when it was understood, and had been shown by the observer's own experience, to be an illusion.* How much a considerable amount of practice in observation under the controlled conditions would in time affect the extent of the illusion was not determined. It is regrettable that under the rare conditions of the illusion at hand the effect of practice was not studied more fully. This may be done, however, in the laboratory. It has not yet been undertaken, I believe, though important studies have been published on the autokinetic illusion from the Chicago University laboratory since this illusion was perceived and partly written up.²

The light on the mountain was simply a camp fire by which some poor fellow was likely drying himself in the rain, wholly unconscious of the part he had played in our experiment. The writer has several times since the experience here described seen illusory movements of lights on mountains, but as, in very case, the lights were not so favorably located and the nights were not sufficiently dark, none of the illusions has been so marked. The movements as a rule have been but short, irregular fluctuations about the true point of the light, resembling more nearly the *Sternschwanken* of the early astronomers.

An illusion of the type here described, which was seen in the writer's childhood, is on the whole still clear in memory. Altogether three or four children and two adults witnessed the phenomenon, which was at the time wholly incomprehensible to the observers. It was regarded as something supernatural. A town about five miles from the one in which we were living at the time had just been, or was being, terribly ravaged by diphtheria. One family in two attacks of the disease had lost seven children, it was reported, leaving only the parents. The scourge had touched the more remote parts of our own town, taking a toll of three children from one

² Carr, H. A., "The Autokinetic Sensation," *Psych. Rev.*, XVII, 1910, 42. Adams, H. F., "Autokinetic Sensations," *Psych. Rev. Mon.*, No. 59, 1912.

family (including the writer's playmate) and one from another family. Stories were current of the dreadfulness of the disease and of how the dead were buried in the night. Beyond this town about seven miles was a mountain range possibly 800 meters in height, affording a favorable field for the illusion. This range, which our line of vision met at right angles, extended many miles both to the right and to the left. The illusion was witnessed on a dark night, and the observers watched it a long time with more interest than that of mere curiosity. It consisted of a large light moving horizontally from side to side over the unfortunate town. We considered it to be some sort of omen having relation to the scourge. Our descriptions, so far as memory serves me, were not specific enough to lead to obvious contradictions; and no one was in a mood to challenge any slight discrepancy. There was, however, some discussion as to whether the light did not have a short tail trailing behind it. I remember distinctly that its movements seemed to be more or less arbitrary, presenting occasional hesitancy and again sweeping at a nearly uniform rate for an apparent distance of one to two or three miles over the town. These long movements do not now seem to have taken more than a few seconds. They were not uniform in length and, it would seem, the light occasionally made actually less progress than the rate of movement would lead one to expect. The light moved only laterally, never up or down, as is now easily comprehensible since the dark field (the distant mountain) was narrow vertically and extended laterally.

Obviously this phenomenon was an autokinetic illusion. The light, which appeared very large even at the distance stated, was doubtless a fire on the mountain about twelve miles from the observers. Because of the state of mind of the persons witnessing the phenomenon, their interest in the neighboring town, the light was erroneously perceived to be the same distance away as the town. Normally in spatial perception our focus is on the object which receives the attention.

Of late, as has already been said, these illusions of movement of lights in dark fields, and of other objects presenting similar movements, have been subjected to careful study in the psychological laboratory. The phenomenon has been described as the autokinetic sensation, or autokinetic illusion. Various explanations of the illusion have been offered. One hypothesis has vaguely attributed the phenomenon to some unknown central factor—a very convenient way of disposing of the matter so long as no real explanation is at hand! Exner

has attributed the movements to overflows of the retinal excitation into portions of the retina near those stimulated. Three kinds of theories have been suggested which attribute the illusion to some sort of eye movements or tendencies to such movements, or to impulses commonly associated with eye movements. It is now well known that small, unconscious eye movements are constantly taking place. These small, quick movements, it has been suggested, may be fused unconsciously in such a manner as to give the impression of a continuous movement of the light in any one direction, or the shifting retinal impressions due to such movements may fuse together with the same general result. But it is difficult to understand how these movements could become integrated to produce the different gross effects experienced.

The second eye-movement theory attributes the illusion to actual eye movements of a considerable extent. Carr has shown, however, that after-images developed previously to the illusion did not bear out this theory; also that the illusion takes place without such eye movements. Illusory movements to the extent of 60 degrees or more may take place with a constant fixation.

The third eye-movement theory—which is, however, in reality an eye-strain theory—holds that the illusion is due to some sort of strain or fatigue in some of the eye muscles, producing an effect of lack of balance which somehow affects one's consciousness or perception of the direction of the light. This theory seems now to be the promising one. I quote a paragraph from a recent supporter of this theory:

"When the eye is at any given position in the visual field, it is held there by the balanced action of the six extrinsic eye muscles. These muscles are not all of equal strength and some will become fatigued more quickly than the rest. When they are in this condition, it will take more of an effort, usually reflex in character, to hold the fixation constant; the fatigued muscle will be more strongly innervated. Consequently, more impulses, kinaesthetic and others, will be sent to the higher centers from that muscle. As these impulses have previously been associated with eye movements in a given direction, and since the fixation remains with the light, the subject will think that the light has moved in the direction in which the strain has been exerted. It produces the illusion of a pursuit movement. It is a matter of indifference whether the nerve impulses from the muscles arouse consciousness immediately or not, so long as they are capable of overflowing into other centers and thus produce the consciousness of movement. The movement must also be attributed to the light and not to the ideational space, for if it were attributed to the ideational space, the movement would be in the direction opposite to that of the strain, whereas it actually is in the direction of the strain."³

³ Adams, *op. cit.*, page 27.

Several experiments seem to support this theory and there are no serious objections to it. It is also obvious that some of the factors pointed out by other eye-movement theories may operate in some aspects of the autokinetic illusions, such, for instance, as are exhibited in the *Sternschwanken*. It must be remembered that perception is a very complex affair physiologically; that the visual perception of direction of any object cannot normally be isolated from that of all other objects in the visual field. When, therefore, the field is dark and presents only a single small light the visual checks by the various other objects are lacking and the illusion is apt to take place. It might be remarked that with only one such single experience there could be no direction sense at all, direction consciousness being—at least in its physiological aspects—wholly a relational affair. Even with the single light, direction must have meaning only in relation to certain marginal experiences or objects (tactual, kinesthetic, visual) and to certain bodily positions, which maintain for the time the general consciousness of the extension and location of the visual field in which the light seems to move. This is amply shown in illusions of direction orientation.⁴ As a result of the formation of wrong visual associations during one's first experiences in a strange city or country, one may be "turned around" ever after in spite of efforts to correct the illusion. One may learn what the true north is and rationally orient one's self, but the *perception* still remains illusory.

It would be interesting to enquire into the frequency of the autokinetic illusion in the normal, or non-laboratory, experiences of man. The well-known *ignis fatuus*, popularly known as the *Will-o'-the-wisp* or the *Jack-a-lantern*, is likely due in large part, so far as its movements are concerned, to this illusion. It is a light that sometimes appears over marshy grounds, caused by the combustion of a gas formed by the decomposition of organic matter, the "marsh gas" or methane (CH_4). The conditions of the appearance of this phenomenon on dark nights (a small light in a large dark field) are entirely favorable for the illusion. It appears from reports of this "marsh light" that its movements are considerable. While some of the descriptions are undoubtedly exaggerated, it must be noted that a movement of 50 to 60 degrees, which under favorable conditions is entirely within the range of possibility, would seem to be extensive.

⁴ Peterson, J., "Illusions of Direction Orientation," *Jour. Phil., Psychol. and Scientific Methods*, XIII, 1916, 225. Other references are there given.